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PRELIMINARY NOTES ON SPECIFYING A REPORT BY AVRO AIRCRAFT LIMITED ON THE C-105 STABILITY PROBLEM

1. The following is an attempt to specify, in a very preliminary way, what should probably be the contents of a report to be written by Avro outlining the situation regarding the stability of the C-105 aircraft. Many groups outside the Company appear to be in the position of requiring a good description of the problem and the progress made to date in dealing with it. The difficulty the Company are in is that it is hard for them to know exactly what information is required in a report suitable for limited outside circulation. They have already given, on a number of occasions, part of the required information, but this does not exist in any self-contained written report. The proposed report therefore probably would include a repetition of some information already given, but this should be included for completeness. Most of this repetition would occur in Part A below.

2. It would appear that this report could be split efficiently into two parts:

   (A) Aerodynamic Stability Problems

   (B) Proposed Methods of Automatic Stability and Control

3. <u>Suggested Contents of Part (A): Aerodynamic Stability Problems</u>

This part would be aimed presumably at showing why a stability problem exists, which must be dealt with by automatic means. This might be done in the following sections:

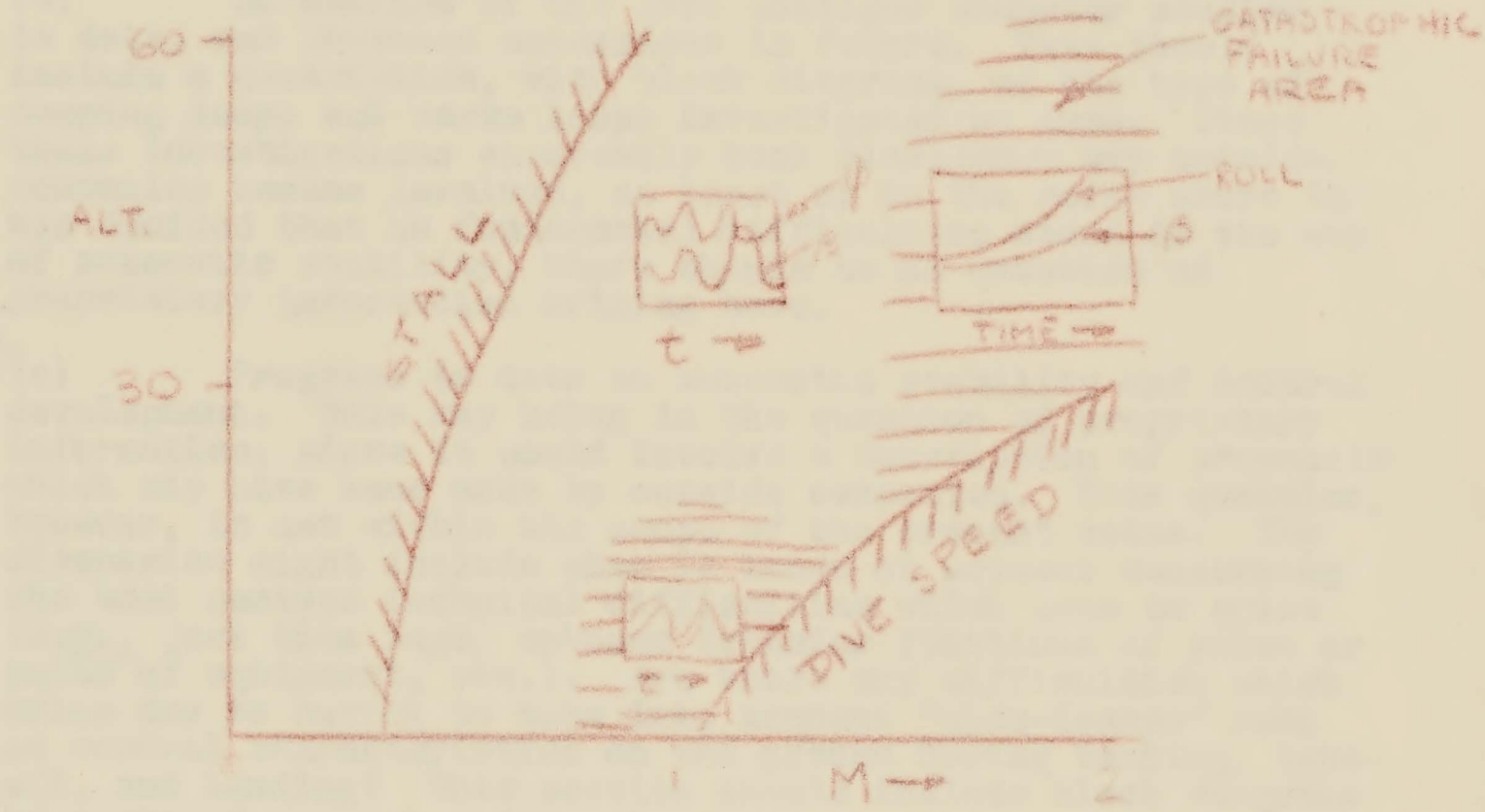
(a) A discussion of aerodynamic static stability. The low values of C_{N_β} pointed out, along with an explanation of the difficulties of dealing with this aerodynamically (e.g. by adding to fin size). Apart from the generally low values of C_{N_β} there should be some discussion of the non-linearities in the C_N curves, and of their importance in the overall stability problem. It would be of interest to know what the Company feels to be the explanation of these non-linearities, and whether they could (or should) be "fixed" by aerodynamic means.

(b) Sufficient curves should be presented to illustrate the discussion under (a) above. For example, curves of C_N versus β at a few angles of attack and Mach numbers

(c) A discussion of dynamic stability without automatic stability and control. A description of the areas within the flight envelope at which the aircraft cannot be flown manually, and a description of the behaviour of the aircraft within these areas (on manual control). Some idea might be given also of

the manual behaviour of the aircraft in parts of the flight envelope outside the actual "unflyable" areas.

(d) A composite figure might be presented to illustrate item (c) above. It could consist of the unflyable areas already given by Avro, but including also small insets showing the qualitative behaviour of the aircraft in the various areas.



(e) The above paragraphs refer mainly to lateral stability. Probably also it would be useful to include some discussion of the longitudinal pitch-up problem, and the progress made to date in curing it. Is progress satisfactory to such an extent that this is no longer a problem? Some curves (C_M vs. C_L) could be used as illustration, to point out the effects of various wing modifications.

4. Suggested Contents of Part (B): Automatic Stability and Control

Part A above should fairly clearly demonstrate the requirement for automatic stability and control. Very little information has yet been given by the Company concerning the details of such equipment. This may be due mainly to the fact that insufficient development work has yet been done to make it possible to be specific. In that case, much of the information requested below can not be given, but this negative fact in itself would be useful information which seems to be lacking.

The discussion might be contained in the following sections:

(a) In view of the above remarks it would probably be of some interest to review the history of the "black box" stability proposal. Did the proposal arise as a direct result of the discovery in the Cornell tunnel of the non-linear directional stability, or was it under consideration before that time for other reasons?

(b) An outline of the Avro analogue computer studies to date, and proposed extensions in future. This should include a description, with block diagrams, of the type of damping loops and servo loops investigated by Avro. Since these investigations apparently took place before any outside companies became involved, at least up to the point where it was decided that no fundamental difficulties stood in the way of automatic stability, there should be no question of proprietary information arising here.

(c) Progress to date on automatic stability and control development. This may bring in the question of proprietary information, since it would involve a description of proposals which may have been made by outside companies. This question, however, is not within the scope of the present notes. The discussion might include what is known at present concerning the most serious technical difficulties which seem to arise (e.g., jack time lags, unknown transfer functions of pilot or parts of equipment, etc.). Are there any difficulties which arise due to having to take into account "side-issues" such as control characteristics on the ground during taxiing, take-off, and landing? This section should include block diagrams of proposed control and damping systems.

(d) Reliability of Automatic Control

Discussion of any estimates which may have been made to date, of the probability of failure of the system in any given time period. What are the most likely modes of failure? Are they such that the damping system merely goes off, or can they result in catastrophe? If the damping system goes off without warning of any kind, does this in effect enlarge the catastrophic areas within the flight envelope? Is warning of failure possible? Is a signal indicating correct operation possible?

5. No mention is made in the above regarding the presentation by Avro of a large mass of detailed data which they possess, such as a complete set of aerodynamic stability derivatives, or the actual transfer functions of parts of the control system. The aerodynamic derivatives have been presented previously to NAE in self-contained reports, and any further detailed data could undoubtedly be obtained by negotiation if it were felt to be necessary. It was assumed in the above notes that the main purpose of the stability report would be to provide a complete, but mainly qualitative, description of the overall stability problem on the C-105 aircraft.